EFFECTIVENESS IN TERMINATING COVER CROPS USING DIFFERENT ROLLER IMPLEMENTS

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ABSTRACT

Rollers may provide a valuable alternative to herbicides for terminating cover crops, however, research has shown that excessive vibration that is caused by the roller passing over the cover crop. To avoid excessive vibration, users must limit their operational speed which reduces the number of producers willing to use this technology. To improve the roller's performance, three different rollers designs were compared: (1) a roller with long blunt ¼ inch steel angle bars equally spaced), (2) a roller with elliptical blunt bars, and (3) a smooth roller with an oscillating crimping bar behind the roller. Preliminary data have shown that the smooth roller with crimping arm produced the highest kill rate of the cover crop (rye, *Cecale cereale L.*). Data indicate that operating rollers at higher speed (5 MPH) produced significantly higher kill rate of the cover crop compared to low speed (1 MPH). Also, the kill rate evaluated at the end of second week from rolling/crimping was 2 times higher as compared to the kill rate at the end of the first week. The minimum vibration levels measured on tractor's frame were produced by smooth roller with oscillating crimping arm. This study provides valuable information to further improve mechanical rollers' effectiveness to terminate cover crops and to give design guidance to researchers who are in the process of developing a mechanical roller widely acceptable to producers in conservation systems.

INTRODUCION

Cover crops are a vital part of conservation tillage systems, but they have to be managed appropriately to get their full benefit. This includes weed pressure reduction and improving soil properties, caused by alleopathy, mulch affects, and increased soil organic matter. In the Southern United States, rye is commonly used as a winter cover crop. Timely termination of cover crops before cash crop planting provides maximum benefits to the main crop (i.e. cotton). Mechanical rollers have been used in some conservation systems but high vibrations and low operating speeds associated with current roller designs have resulted in a low rate of adoption by farmers.

A report by CTIC (2003) shows that between 1990 and 2002, the number of U.S. cropland acres planted in conservation systems without surface tillage increased from 73.2 million acres to 103.1 million acres. This significant increase can be attributed by positive benefits of winter cover crops as an integral component of conservation tillage systems. Several studies have identified these benefits, such as increased water infiltration, reduced runoff, reduced soil erosion, and reduced detrimental effects of soil compaction (Reeves, 1994; Raper et al., 2000a; Raper et al., 2000b).

Most agricultural extension services recommend terminating the cover crop at least two weeks prior to planting the cash crop. This should prevent the cover crop from using valuable spring moisture that could be used by the main cash crop after planting. Killing cover crops has been accomplished mainly by use of herbicides, since spraying is relatively fast and inexpensive. However, for a cover crop (rye) that is very tall and lodged in multiple directions planting may be affected. According to Raper (2004) flattening and crimping cover crops by mechanical rollers is widely used in South America, especially Brazil to successfully terminate cover crops without a need to use herbicides.

Because of potential environmental and monetary benefits (no use of herbicides) this technology is now receiving increased interest in North America. Cover crop rollers have historically consisted of round drums with equally spaced blunt blades around the drum's perimeter. The function of the blades is to crimp or crush the stems of the cover crops without cutting them, otherwise, the cover crops can re-sprout and residue may interfere with planting operations. Ashford and Reeves (2003) investigated benefits of rolling a cover crop. They indicated that when rolling was conducted at the correct stage of plant growth, the roller was equally effective as chemical herbicides at terminating the cover crop. Also, the power required for rolling was significantly reduced as compared to the amount of power required to mow. Another important aspect of rolling is that a flat mat of cover crop lies in the direction of travel. This allows for farmers to use planter-seeders operating in parallel to rolled cover crop direction, which has been successful in obtaining proper plant establishment. Using rollers alone to flatten the cover crop and prevent multiple-direction lodging could be also beneficial.

Some North American producers have reported problems with these implements. The main complaint has been the excessive vibration that the rollers generate. The most effective method of alleviating the vibration, but not desirable and not economical, has been to reduce travel speed. However, most producers find this to be an unacceptable solution due to the much higher operating speeds that they were able to previously spray herbicides onto their cover crops.

The objectives of this paper are therefore: to compare effectiveness of three rollers to terminate cover crops, to compare vibration levels generated by the three rollers, and to determine effect of speed on cover crop termination and vibration levels.

MATERIALS AND METHODS

Experiments were conducted at the Alabama Agricultural Experiment Station E.V. Smith Research Station on Compass sandy loam soil (thermic Plintic Paleudults) near Shorter, Alabama. Rye was planted in fall 2003. Before testing of different roller designs, height (10 counts per plot) of rye was recorded. The experiment was conducted in mid-April, 2004 when the cover crop was in the soft dough growth stage (Nelson et al., 1995) which is a desirable growth stage for termination. Measurements of cover crop biomass were taken from a 0.25-m^2 area within each plot. The kill rate was evaluated on a weekly basis by visual ratings (0 to 100% control scale) at one, two, and three weeks after rolling treatments.

Experiment design.

Three different roller designs of a 5.8-ft single section width were used to determine performance of each roller design in terms of maximizing termination rate and minimizing vibrations while operating at the optimum speed. A completely randomized block experiment was conducted with four replications comparing three crimper designs and three tractor speeds. Three different treatments of various roller designs were used: (1) long-straight blades (Fig 1a), (2) curved blades (Fig 1b), and (3) smooth roller with an oscillating crimping arm (Fig 1c). The operating speeds were setup to 1, 3, and 5 mph. Accelerometers from Crossbow Technology Inc. (San Jose, CA) were mounted on the roller's frame to measure vibrations due to roller motion (Fig 2a) and on the tractor's frame to measure vibration levels to which driver was subjected (Fig 2b). The data were analyzed with SAS Analyst linear model. A significance level of $P \le 0.1$ was chosen to separate treatment effects.

RESULTS AND DISCUSSION

Discussions will cover main treatment effects: type of roller, speed of implement and time (week) elapsed from rolling/crimping procedure.

Type of roller.

Following two weeks of rolling/crimping of rye, the smooth roller with crimping arm had a significantly higher kill rate (33% kill) as compared to the roller with curved blades (29%) (Fig. 3; $P \leq 0.04$). Also, there was no statistical difference between smooth roller with crimping arm and the design with long blunt blades (31%).

Speed of implement.

With increased speed of implement, there was an increase in killing rates. Significant differences were observed between speeds of 5.0 MPH (33%) and 1.0 MPH (30%), (Fig. 4; $P \leq 0.09$). There was no statistical difference between speeds of 5.0 MPH (33 %) and 3.0 MPH (32 %).

Time (in weeks) following rolling/crimping.

There was a significant difference between the time elapsed since rolling/crimping. After the first week, 21% of the cover crop was killed and after the second week, 41% of the cover crop was killed, (Fig. 5; $P < 0.0001$). For the second week after rolling, the highest kill rate was produced by the smooth roller with the oscillating crimping arm (44% kill) followed by straight roller (40.8% kill) and curved blade roller (39% kill).

Vibration level.

There was a significant difference in increasing the vibration levels on roller frame with increased operating speeds for all the roller types (Fig. 6; $P < 0.0001$). The lowest vibration level at roller's frame was recorded for curved blades roller's frame (0.21 G-accel.) which was significantly lower than for straight long blades (0.50 G-acc) and smooth roller with crimping arm (0.47 G-accel.) (Fig. 7). However, there was no statistical difference in vibrations levels measured on roller's frame for smooth roller with crimping arm and the original design with long blunt blades. The vibration levels measured at the tractor's frame for all roller types and speeds is shown in Fig. 8. There was no significant difference in vibration levels transferred to tractor for 1.0 MPH and 3.0 MPH, however, significant differences occurred at 5.0 MPH for all roller types (Fig. 8; $P \leq 0.014$). Vibrations transferred to the tractor from the straight long blades roller across all speeds were significantly greater (twice higher, 0.22 G-accel.) than for rollers with curved (0.10 G-accel.) and smooth with crimping arm (0.09 G-accel.) blades (Fig.9).

CONCLUSIONS

Kill rates of cover crop (rye) differed significantly among roller types for the first 2 weeks of the test, with the maximum kill rate being obtained by the smooth roller with crimping arm.

Higher operating speeds of the roller produced significantly larger kill rates as compared with lower operating speeds.

Increasing time from rolling/crimping significantly increased kill rate between the first and second week.

At the maximum speed of operation, the minimum vibration levels measured on the tractor's frame were produced by the smooth roller with oscillating crimping arm, followed by higher (but not significantly different) for the roller with curved blades. The roller with straight long blades produced the maximum and significantly higher (twice) vibration levels on the tractor's frame in comparison with curved blades and smooth-crimping arm rollers.

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Figure 1-Roller types. (a) Roller with attached long straight crimping blunt blades, (b) roller with attached curved elliptical crimping blunt blades, (c) smooth roller with an oscillating crimping arm with blunt blades.

A.

B.

C.

Figure 2-Location of accelerometers mounted: (a) roller's frame, (b) Tractor's frame

A.

B.

Figure 3-Percent kill of cover crop (winter rye) for different roller types averaged over time and speed.

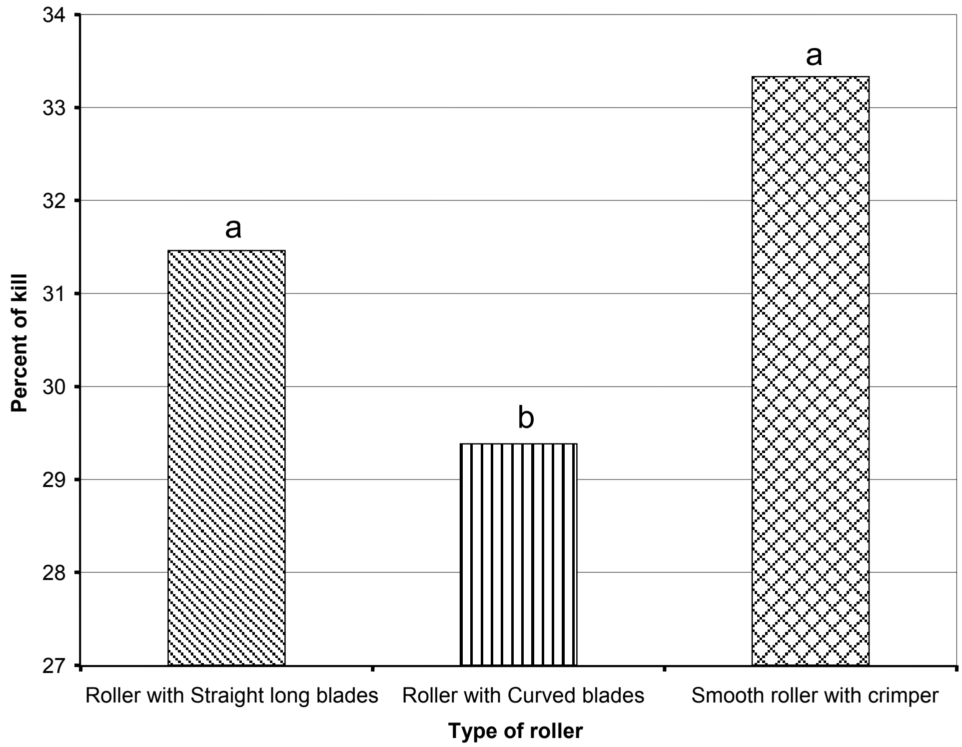

Figure 4- Percent kill of cover crop (winter rye) for three different speeds and roller types averaged over time.

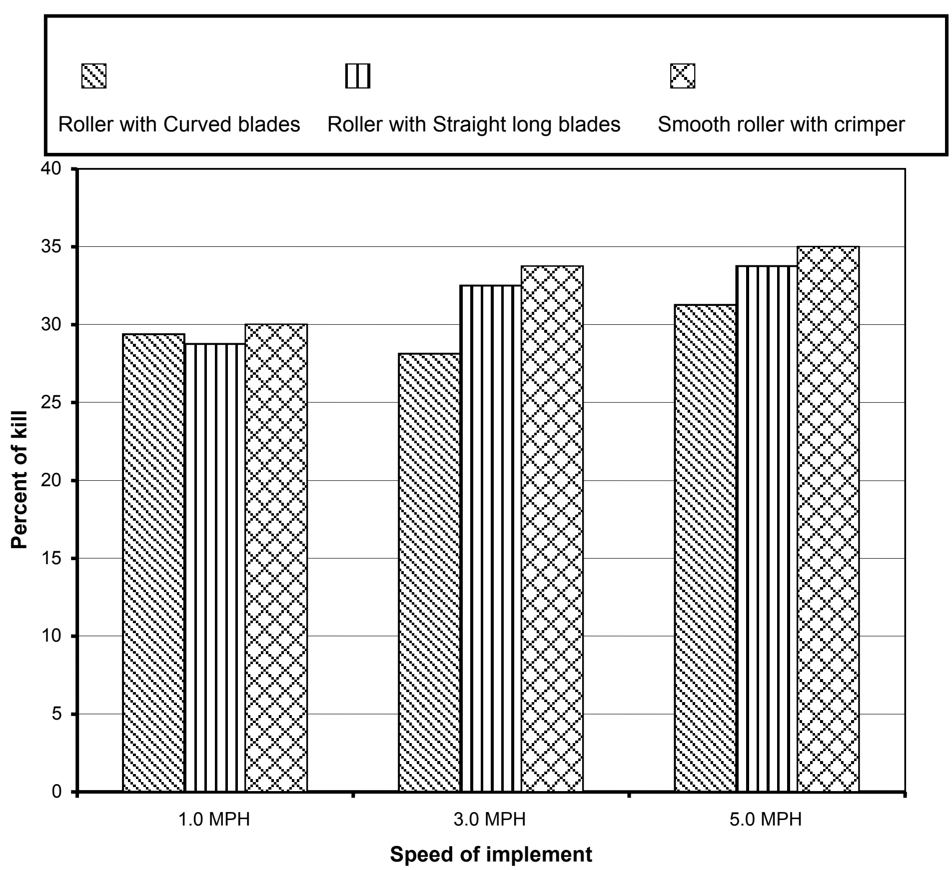

Figure 5-Percent kill of cover crop (winter rye) for time elapsed (weeks) from rolling and roller types averaged over speeds.

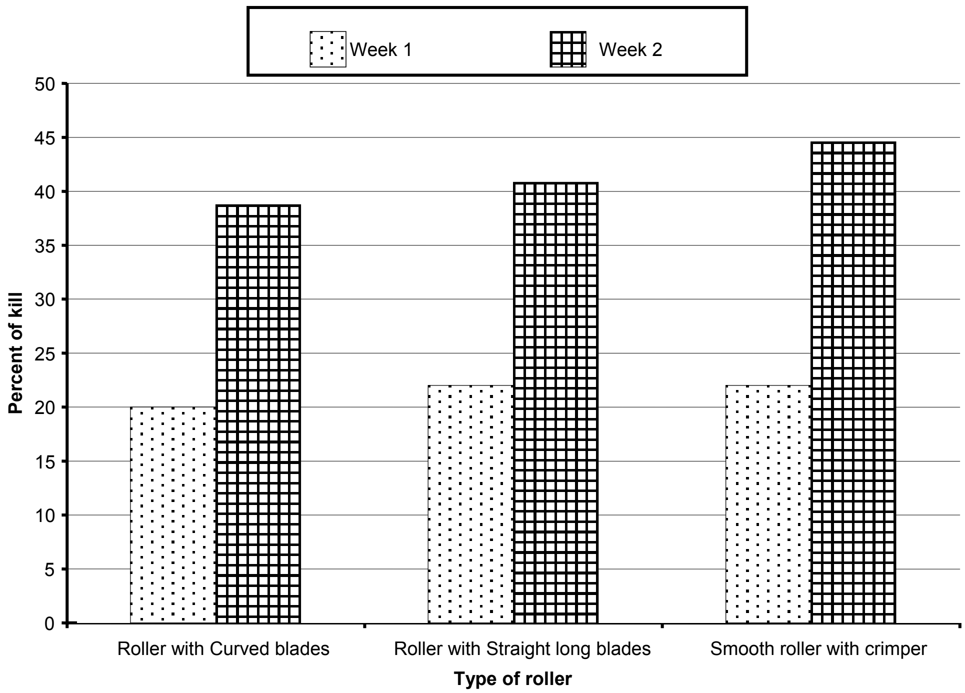

Figure 6-Vibrations levels measured at roller's frame produced by different roller types for 3 different speed levels.

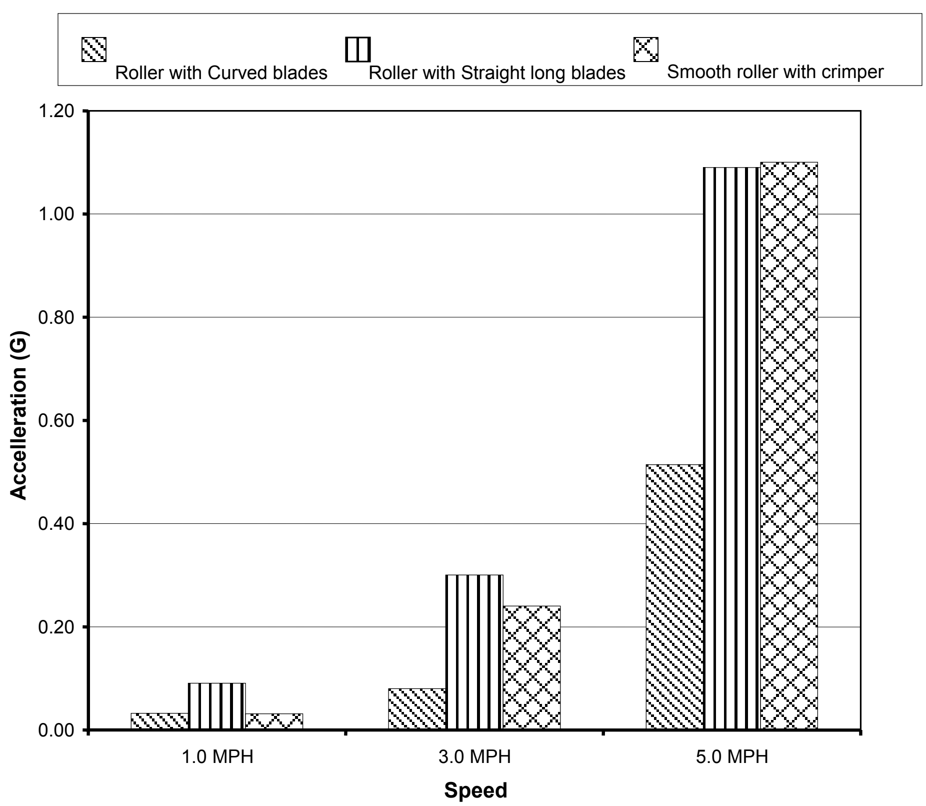

Figure 7-Vibrations levels measured at roller frame produced by different roller types across all speeds.

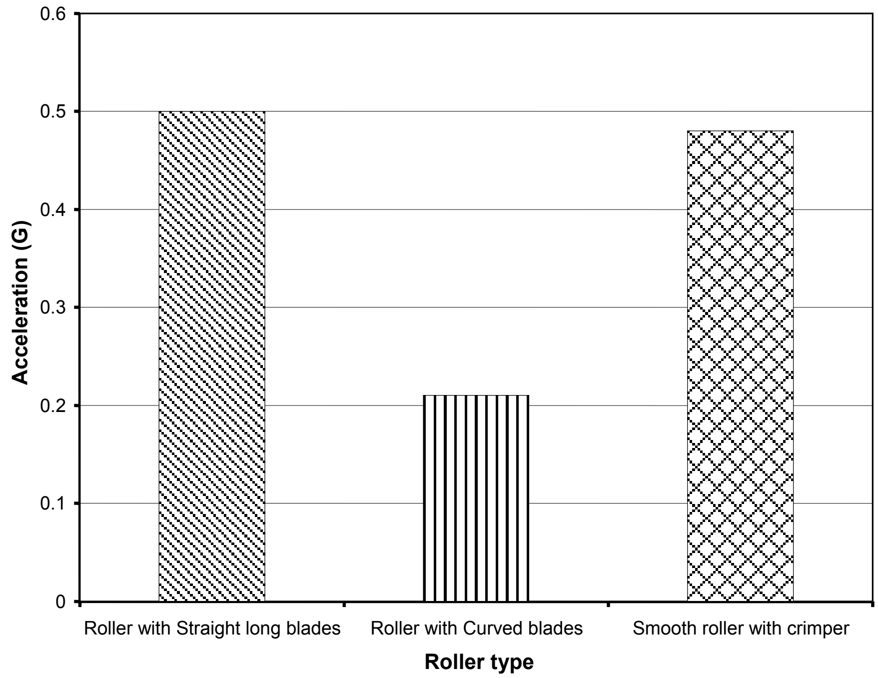

Figure 8-Vibrations levels measured at tractor's frame produced by different roller types for 3 different speed levels.

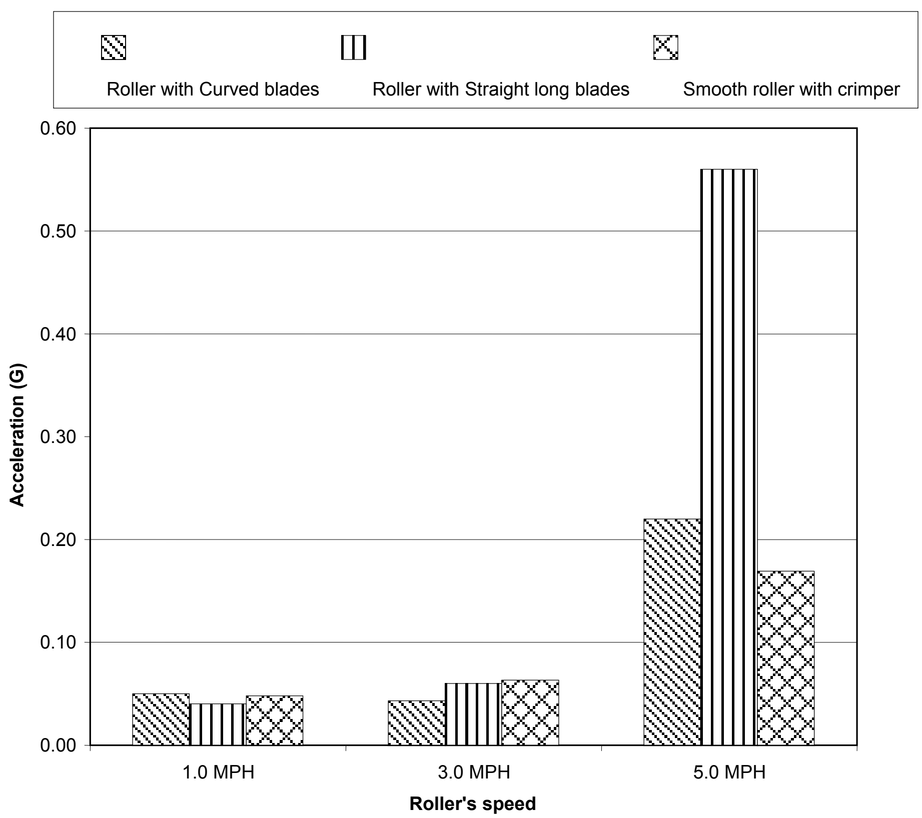

Figure 9-Vibrations levels measured at tractor frame produced by different roller types across all speed levels.